

18. Jet streams follow the sun in that as the sun's elevation \_\_\_\_\_ (increases, decreases) each day in the spring, the jet stream shifts by moving \_\_\_\_\_ (north, south) during the Northern Hemisphere spring.
- (A) increases, north
  - (B) increases, south
  - (C) decreases, north
  - (D) decreases, south
  - (E) none of the above
19. Usually, fair and dry/hot weather is associated with high pressure around \_\_\_\_\_ latitude with rainy and stormy weather associated with low pressure around \_\_\_\_\_ latitude.
- (A) 0 degrees N/S, 90 degrees E/W
  - (B) 90 degrees E/W, 90 degrees N/S
  - (C) 30 degrees N/S, 50–60 degrees N/S
  - (D) 50–60 degrees N/S, 30 degrees N/S
  - (E) 45 degrees N/S, 45 degrees E/W
20. The three necessary ingredients for thunderstorm formation are
- (A) moisture, lifting mechanism, instability
  - (B) lifting mechanism, mountains, oceans
  - (C) stability, moisture, heat
  - (D) lifting mechanism, fronts, moisture
  - (E) deserts, mountains, clouds

## FREE-RESPONSE QUESTION

Characteristics of air masses and their worldwide circulation patterns influence the spatial distribution of biomes and the organisms that inhabit them.

- (a) Describe a Hadley, Ferrel, or polar cell in terms of what it is, how it develops, and its locations in reference to the equator.
- (b) Describe the characteristics of that cell in terms of climatic conditions such as temperature, relative humidity, prevailing winds, and so on.
- (c) Describe one biome that would exist at sea level within the specific latitudes of that cell. Give examples of both plants and animals that would exist within that biome.

### TIP



Before writing your essays, be sure to map out or brainstorm what you are going to write about. A few minutes planning and organizing your essays will get you a much higher score.

## MULTIPLE-CHOICE ANSWERS AND EXPLANATIONS

1. (C) The troposphere is the atmospheric layer closest to Earth and extends for about 11 miles (18 km) above Earth at the equator and about 5 miles (8 km) above Earth at the poles. Temperature declines as altitude increases.

2. (E) Nitrogen (78%), oxygen (21%), water vapor (about 0–4%), and the rest below 1%.
3. (A) Latitude expresses how far north or south of the equator a location is. The equator is 0° latitude, and the poles are at 90°. For every 1,000 feet (300 m) in altitude, there is a 3°F (1.5°C) drop in temperature.
4. (D) A low-pressure air mass (low) occurs when warm air, which is less dense than cooler air, spirals inward toward the center of a low-pressure area. Since the center of the low-pressure area is of even less density and pressure, the air in this section rises and the warm air cools as it expands. The temperature begins to fall and may go below the dew point—the point at which air condenses into water droplets. These water droplets make up clouds. If the droplets begin to coalesce on condensation nuclei, rain follows.
5. (C) During La Niña, large portions of central North America experience increased storminess, increased precipitation, and an increased frequency of significant cold-air outbreaks, while the southern states experience less storminess and precipitation. Also, there tends to be considerable month-to-month variations in temperature, rainfall, and storminess across central North America during the winter and spring seasons.
6. (D) The rain shadow effect occurs on the leeward side of a mountain, the side away from the ocean. Moist air from the ocean rises when it hits mountains, cools, and loses its moisture on the windward side. On the leeward side, air is much drier. For example, the western side of the Sierra Nevada Mountain Range in California is much wetter than the eastern side.
7. (B) 97% of ozone (O<sub>3</sub>) is found in the lower stratosphere, which is 9 to 35 miles (15–55 km) above Earth's surface. Temperature increases with altitude in the stratosphere due to absorption of heat energy by ozone molecules.
8. (A) Hadley cells occur between 0° and 25° north and south latitudes (equatorial region). In this area, there is upward air motion, cooling of the air due to uplift, high humidity, high clouds, and heavy rains.
9. (A) Water vapor is present in such abundance throughout the atmosphere that it acts like a blanket of insulation, trapping heat and forcing surface temperatures higher than they would be otherwise. Water vapor is roughly eight times more effective than carbon dioxide as a greenhouse gas.
10. (E) During monsoon season, winds blow from cooler ocean areas (higher pressure) to warmer landmasses (lower pressure). As the air rises over the land masses, it cools and is unable to retain water, producing great amounts of precipitation. In winter, the ocean is now warmer and the cycle reverses. Drier air travels from the land out to the ocean. Monsoons exist in Australia, Africa, and North and South America.
11. (A) Temperature inversions are atmospheric conditions in which the air temperature rises with increasing altitude, holding surface air down and preventing dispersion of pollutants.
12. (E) Albedo is a measure of reflection of sunlight from a surface. Of the choices, dark topsoil absorbs the most energy and therefore reflects the least amount of energy, resulting in the lowest albedo.
13. (D) Jet streams are large-scale upper air flows that travel from west to east and are produced by differences in temperature. They can travel as fast as 250 miles per hour (400 kph) and travel between 3 and 8 miles (5–13 km) above Earth's surface.

14. (B) Remember, the question required you to place the layers in order from the most distant to the closest.
15. (B) In a high-pressure system, air pressure is greater than the surrounding areas. This difference in air pressure results in wind. In a high-pressure area, air is denser than in areas of lower pressure. The result is that air will move from the high-pressure area to an area of lower pressure. Clear skies and fair weather usually occur in these regions. On the other hand, winds tend to blow into a low-pressure system because air moves from areas of higher pressure into areas of lower pressure. As winds blow into a low-pressure system, the air moves up. This upward flow of air can cause clouds, strong winds, and precipitation to form.
16. (D) Hadley cells dominate the tropics.
17. (A) The seasons in the Southern Hemisphere are opposite that of the Northern Hemisphere. For example, spring in the Northern Hemisphere is fall in the Southern Hemisphere.
18. (A) The position of the jet stream also determines where the storm track is. As the jet stream moves north during spring, the storm track moves north, leaving the southern plains of Texas and Oklahoma and moving into the northern plains near the Dakotas.
19. (C) Except for a few locations, most of the world's deserts are located along 30 degrees N/S with lush forests from abundant rains located around 50–60 degrees N/S.
20. (A) Moisture, a lifting mechanism, and instability are all needed for thunderstorms to form. The moisture is needed for rain. The lifting mechanism is needed to get the air moving initially in an upward direction, and the unstable atmosphere insures the upward-moving air continues to do so.

## FREE-RESPONSE ANSWER

Let's do this essay together, using it as a teaching tool rather than just providing an answer and rubric. Let's choose the Hadley cell for this example.

The first step is to brainstorm. Write a list of key words that would apply to the question. Remember that the order of the keywords is not important, we will put them into the correct order later. Here is a sample of key words: Hadley, Ferrel, polar, temperature, solar insolation, humidity, biomes, plants, and animals.

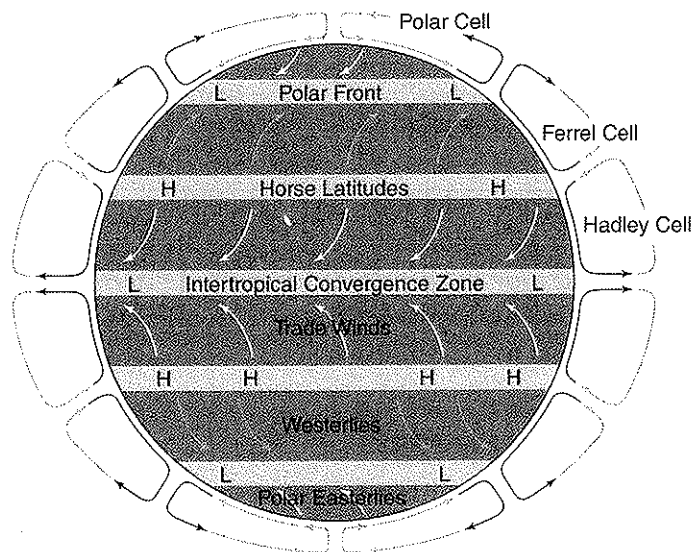
Now that we have around 10 key words, let's expand the list by adding details—items that we will discuss in our essay. We can also begin to map out the order in which we will discuss the items.

- Hadley: 0° to 30°, deserts, equatorial regions, tropical rain forests, subtropical areas, savannas
- Location
- Temperature (heat moves from equator to colder areas)
- Relative humidity
- Prevailing winds
- Solar insolation
- Biomes
- Animals
- Plants

Remember, you have 23 minutes to spend on this essay, so do not spend more than 5 minutes in organization. Now look over the list and add anything that you have missed. Now it is time to begin writing.

The first step is to write a thesis statement: **“The world’s biomes are primarily determined by climatic conditions. Deserts are characterized as areas of low precipitation, while tropical rain forests are characterized by areas of high precipitation.”**

The next step is to begin describing what determines climatic conditions that, in turn, affect the type of life present within that zone. **“Solar insolation, that is the amount of sunlight received on Earth, is greatest at the equator and diminishes toward the poles. Since heat flows from warmer regions to cooler regions, the warmer air produced at the equator moves through major worldwide wind patterns that distribute this energy worldwide. As one moves from the equator to the poles, there are three major air circulation cells—Hadley, Ferrel, and polar.”** At this point, a labeled sketch would be helpful.



Now, for the remaining time, we can refer to the detailed essay outline and complete the essay, adding details and examples where necessary.

From the equator to 30° north and south latitudes, Hadley cells exist. Since this area of Earth receives the greatest solar radiation due to Earth’s axis tilt, this area of Earth is the warmest. Near the equator, this warm, moist air rises. As the warm air rises, it begins to cool and become denser. Since cooler air cannot hold as much water vapor as warmer air, the humidity of the air increases to the point where clouds are produced. This, in turn, causes great amounts of rainfall. Monthly average temperatures are quite high at sea level, and there is no winter. Vegetation near sea level is tropical rain forest. In these tropical systems, temperature variations from day to night are greater than from season to season. Tropical rain forests, which extend about 1,500 miles (2,400 km) north and south of the equator, are found in South and Central America, Africa, and southeast Asia. Climatic conditions can include rain

throughout the year, monsoons—a short, dry season followed by a heavy, rainy period, and tropical savanna with characteristic wet and dry seasons.

Tropical rain forests have characteristically high-species plant and animal diversity. Vegetation is dense. Bromeliads, orchids, ferns, and palms are present. Leaves are large in an effort to absorb sunlight, and there is little need to conserve water lost through transpiration. Soils are characteristically low in nutrients with the nutrients being stored in vegetation. Soil is characteristically acidic. Decomposition of organic material is high due to temperature and moisture. Leaching of soil nutrients is high; therefore, soil quality is very low. Abundant insects and animal biodiversity are characteristic. Examples of animals that one might find in a tropical rain forest biome might include numerous species of butterflies, ants, mosquitoes, millipedes, bats, monkeys, sloths, tarsiers, hippopotamuses, macaws, toucans, parrots, anacondas, alligators, and numerous species of frogs.

At this point, we think we are done. Our last job is to be sure that we have answered all questions. Let's put a check beside each topic that we answered and that we were required to address:

- Describe the cell ✓
- How it develops ✓
- Location of the cell ✓
- Characteristics of the cell
  1. Temperature ✓
  2. Relative humidity ✓
  3. Prevailing winds ✓
  4. Solar insolation ✓
- List examples of plants and animals living within a biome in that cell ✓

Now it is your turn. Take the same question, but this time answer it in terms of either a Ferrel or polar cell. Your teacher may wish to collect your essay and give you pointers on your strengths and weaknesses.